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# THE INFLUENCE OF COMMUNICATION TECHNOLOGIES ON ORGANIZATIONAL STRUCTURE: A CONCEPTUAL MODEL FOR FUTURE RESEARCH

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**ABSTRACT**
The objective of the article is to conceptually integrate communication related dimensions of knowledge-based tasks in a simplified model. The initial information of the model is a static interrelation of task dimensions, and organizational structural forms most effective for tasks described in terms of these dimensions. The dynamic version of the model consists of the hypothesized relation between organizational structure and communication related information technologies, such as sophisticated electronic mail, systems computer-conferencing, and document search and retrieval systems, in enhancing communication, and consequently, task performance.

The metrics of the conceptual model's dimensions, and the model's applicability to future research of communication, and to managerial practice in the technological era are discussed.

## ORGANIZATIONAL COMMUNICATION AND PERFORMANCE

The determinants of technical communication patterns in R&D organizations have been the subject of a considerable amount of study in recent years (Allen, 1984; Allen, Tushman, & Lee, 1979; Allen, Lee & Tushman, 1980; Katz & Allen, 1982).

A very large body of research (Shilling & Bernard, 1964; Pelz & Andrews, 1966; Allen, 1984) shows communication among technical professionals in R&D laboratories to be a significant determinant of technical performance and the productivity of R&D project teams. A recent study carried out in a major computer firm by Hauptman (1986a, 1986b) corroborates these findings for software development and production, as well.

These studies further demonstrate that communication patterns in such organizations are determined largely by two factors: organizational structure and the physical location of people. The present paper will focus on the first of these and will examine the ways in which information technology affects the relationship between organizational structure and technical communication.

## INFLUENCE OF INFORMATION TECHNOLOGIES ON ORGANIZATIONAL COMMUNICATION

One cannot discuss organizational communication at the present without at least speculating about the impact that the explosive development in communication-related information technologies will have on them.

The following rational-economic assessment of digital communication is probably typical of the enthusiastic perception about the benefits new communication-related information technologies promise:

> . . . The phone also shares a problem with all speech communication: the information density of speech is very low. Generally, the electronic transmission of speech requires about 60,000 bits per second. These 60,000 bits of speech carry about the same information as 15 characters of written text... But you can transmit 15 characters directly as text by transmitting only 120 bits of information, rather than 60,000 bits of speech. . . . In a very fundamental sense, speech is not an economic medium of communication (Marill, 1980: 185).

It might seem that the new technologies, such as electronic mail or computer-mediated conferencing, would offer many advantages in comparison with oral communication. Picot, et. al. (1982) list such advantages as effective decentralization of autonomous work groups, including work at home. Hiltz & Turoff (1978: 8-9) in their detailed case study of a computer-conferencing package suggest that:

> 1. Time and distance barriers are removed. Participants can send and receive communications whenever it is convenient for them, with the material . . . to be received or revised . . . again and again . . .
>
> 2. Group size can be expanded without decreasing actual participation by either member. . . . No one can be interrupted or 'shouted down'. In addition, since it is possible to read much faster than listen, much more total infromation can be exchanged in a given amount of time.
>
> 3. A person participates at a time and rate of his or her own choice. You need not leap out of the bathroom to answer a ringing telephone, or drag yourself out of a hotel bed at 7a.m. to make a meeting that begins at 9a.m.

This positive outlook is shared by some practitioners, e.g., Roger Smith, Chairman of General Motors who refers (1985: 5) to information communication technologies as the vehicle for what he calls the "21st

Century Corporation". According to Smith it entails:

> . . . an integrated, coordinated, decision-making way of functioning which comprehends business plans, budgets, product programs, corporate volumes, and everything else that helps run the business. it must create an integrated worldwide data base that brings all parts of the busines together.

If Hiltz & Turoff (1978) see the main application of information technologies as replacing and complementing face-to-face and telephone interactions, Smith (1985: 6) predicts the replacement of paper-based information and communication:

> Just as automobiles of today are increasingly moving from mechanical controls to elctronic controls, so must the businesses of today switch from paper to an electronic flow of data.

This enthusiasm for a new set of technologies relevant to management is still in need of rigorous, empirical evidence in real-life industrial and governmental settings. Nevertheless several important findings should be mentioned. Hiltz & Turoff (1978) provide detailed protocols of interactions via a computer-conferencing package, and suggest that it could possibly replace other media of communication, such as face-to-face, telephone and mail. It also seems that the electronic text medium is inherently disciplined because of the cognitive structure imposed by the written medium; it should presumably filter out the affective components of human interactions (see for instance Johansen, Valee, & Collins, 1977; Johansen & DeGrasse, 1979).

The asynchronous nature of computer-mediated interactions also make them more egalitarian. They are less influenced by status, or the verbal

eloquence or aggressiveness of the individual. Both Hiltz and Turoff (1978), and Siegel, et. al. (1984) show that participation in discussions is more equally distributed among participants than could be expected in similar face-to-face groups.

The natural question that should be asked is about efficiency and effectiveness of computer-mediated communication. For instance Siegel et al. (1984) found that it usually took the computer-mediated groups longer to reach a solution. Possibly the fact that these groups exchanged fewer remarks than face-to-face groups impaired the flow of task-relevant information. It should be mentioned, though, that the computer-mediated groups were as task-oriented, and more quantitative than face-to-face groups. In addition, Sproull & Kiesler (1986) found that much of the information conveyed through this medium would not have been conveyed without it.

These findings are indicative of the potential benefits and limitations imposed by the medium. Obviously, the efficiency of transmitting digital data via the computer, described by Marill (1980), narrows the band in the same ratio, in this case by 500 (60,000 to 120). The 60,000 bits of speech are transmitting not only 15 characters of verbal data but also vocalization - pauses, pitches and tones.

Even the traditional voice medium, the telephone, is incomparably more narrow-banded than face-to-face interactions. It totally lacks the visual channel, which includes the physical attributes of the person. This screening can be regarded as positive because it could prevent potential biased responses, based on individual attributes unrelated to

the task. Obviously, the medium screens out facial expressions, eye contacts, body movements, and psycho-physiological responses, but the importance of these cues remains problematic (Allen, D., & Guy, 1979).

Furthermore, the questions of what are the realistic benefits that can be derived from communication-related information technologies to organizations remain unanswered. To what extent these technologies have the potential to show results at the "bottom line", and in what ways. Clearly, some organizational tasks are more amenable to productivity increase through information technologies than others, which might appear quite similar. It is clear that the exploitation of these technologies has to be administered with insight about communication-related issues, and with great organizational astuteness in implementing them.

Several recent papers address electronic mail implementation in business organizations, and are highly relevant. For instance, Picot, et. al. (1982) in their detailed field study of how the various communication media found that managers perceive face-to-face and telephone to be superior to the indirect, asynchronous channels for stimulation and privacy (with the exception of mail, which rated quite well for privacy). On the other hand, TELETEX[1] is perceived highest on dependability and rates better than face-to-face for comfort and formality. On the task-oriented dimensions TELETEX is perceived superior than face-to-face in terms of promptness and accuracy, but is definitely worse on complexity of transmitted information, and confidence about the

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[1]TELETEX is a trade name of an European public domain electronic mail, similar to QUICKCOM and DIALCOM.

information reaching its destination. The authors also provide data about perceived restructuring in channel utilization: TELETEX does not seem to be a very strong competitor of face-to-face communication (only 5 percent replacement); mail and telephone rate only somewhat better with 12 percent and 18 percent potential replacement by teletext. Because it measured perceptual, subjective data, this study still leaves open the issue of actual restructuring of communication when computer-based media are introduced.

There are several studies which come close to addressing the central issues of use, implementation, and benefits that could be expected from information technologies. Steinfield's study (1984, 1985) is an effort to clarify the typology of communication tasks that could be performed effectively via electronic mail. He found a clear distinction between social and task usages, and to what extent each sub-task was susceptible to mediation by electronic mail. His results support the Picot, et. al. (1982) warning about over estimating the impact of communication-related technologies on complex tasks. He found that such tasks as "carry on negotiations/bargaining", "resolve conflicts/disagreements", "discuss confidential matters", had never been carried out via the computer by at least 50 percent of the respondents.

Culnan (1985) addressed the narrow issue of perceived accessibility of the medium as a determinant of its use. Her results suggest that physical access to a system is a necessary, but insufficient condition. Controlling for the other variables, system usage correlated significantly only with knowledge of the command language, and information accessibility, but not with terminal accessibility, or

overall reliability of the system. Her results validate and update what Gerstberger & Allen (1968) found about the importance of accessibility as a determinant of source utilization.

Another critical question concerns the specific capabilities of communication-related information technologies. It is still unclear the extent to which the existing technological options such as electronic mail, computer-conferencing, bulletin boards, and document search and retrieval systems differ from each other in accomplishing organizational objectives. Probably an equally important question revolves around the task types for which they provide comparative advantages. The central issue is to match taxonomies of tasks and communication related information technologies. Using Watzlawick, et al. (1967) definitions, "analogue" communication might continue to elude the computer-based media. Steinfield & Fulk (1986) addressing this issue found limited support for a related hypothesis that task analyzability should be associated with use of elctronic mail, while job pressure and geographic dispersion spurred more frequent use of this medium. In this context, studies by McKenney and collaborators (McKenney, 1986; McKenney, Doherty, & Sviokla, 1986) suggest that electronic mail systems could be effective for managerial communication only when supplemented by face to face contact (McKenney, et al., 1986: 22):

> The combination of EM [Electronic Mail] and FTF [Face-to-Face] eliminated the anonimity and lack of non-verbal cues that could reduce social inhibitions and create social-psychological problems . .

**THE INFLUENCE OF STRUCTURE ON COMMUNICATION IN R&D: A CONCEPTUAL MODEL**

Communication playes a central role in achieving two goals that are critical to the performance of an R&D organization:

1. The activities of the various disciplines and specialties must be coordinated in order to accomplish the work of multi-disciplinary tasks.

2. Tasks must be provided with state-of-the-art information in the technologies they draw upon.

A trade-off between these two goals has spawned various organizational forms and structures. When the organization is built around specific disciplines or technical specialties, i.e. a functional (or matrix) organization, it will most effectively accomplish the second goal of <u>maintaining current technological know-how</u>. When R&D professionals are grouped into project teams working toward a common output goal, <u>coordination of activities</u> will be accomplished more effectively.

The reasons for thsi are very straightforward. The functional organization, by grouping together people who share a common base on knowledge enables them to keep one another informed of new developments in that area of knowledge. The project organization, by grouping together people who are working on a set of related problems, enables those people to better coordinate their efforts on that set of problems. Allen (1984, 1986) has shown that there are three factors that determine which of the two organizational forms will be preferred in any instance.

The following conceptual model is based on the informational needs of typical R&D tasks, and shows how project and functional structures help to accomplish them. The model is closely linked with the organizational

information processing tradition (e.g., Tushman & Nadler, 1978; Daft & Macintosh, 1981), and its more recent articulation in studies of advanced information technologies (see literature review in Steinfield, 1985). The model addresses information processing on the task level, with implications for structural design on a departmental or functional basis. It defines an "Organizational Structure Space" and is based on the following premises: first, technologies vary in their rate of development, and in the rate at which new knowledge is generated; some technologies, such as metal processing, or oil refining, are presently more mature and stable, others, e.g., bio-engineering, or the development of superconducting materials are more dynamic. The rate of change of technological know-how, defined as the first derivative of knowledge with time, dK/dt, serves as one coordinate of the Organizational Structure Space; the higher the value of dK/dt, the stronger is the need for effective transfer of state-of-the-art technology. Consequently, the greater the need for the specialty oriented functional structure to accomplish this. Although there is some similarity between this dimension and Perrow's (1967) typology of technological "non-routiness" (see also Whitey, Daft, & Cooper, 1983), or to Tushman & Nadler's (1978) environmental uncertainty, these constructs lack the specific meaning of this dimension for technical activities on the task level.

The second dimension of the decision space is related to the requirement for organizational coordination, of bringing together the expertise of different professionals toward a single output goal. It is the interdependence among sub-systems and components which the task comprises. The higher this interdependence ($I_{ss}$), and the mutual co-influence of these sub-tasks in the joint effort, the stronger is the

demand upon the task team for coordination of its activities. This dimension cuts across Tushman & Nadler's (1978) intra- and inter-unit task interdependence by looking at it as a task attribute, rather than a structural relationship. On the other hand, it is based to some extent on Thompson's (1967) typology of task interdependence, and its articulation by Van de Ven, & Delbecq (1974), and Van de Ven, et. al. (1976).

The third dimension of the Organizational Structure Space is also related to the need for acquisition of technical information -- the duration of the task. If the task (T) is comparatively short, a person working in even a rapidly advancing technology is unlikely to lose touch with its state-of-the-art. On the other hand, in a long assignment of several years, being isolated from peers in the specialty or discipline will carry the dangers of professional obsolescence. This notion is reinforced on the group level by the effects of the Not Invented Here Syndrome (Katz & Allen, 1982).

The resulting Organizational Structure Space combines the three dimensions (Figure 1). The prescriptions emerging from this graphic representation are simple conceptually, although the quantitative assessment of the three variables could prove to be elusive. Qualitatively though the prescriptions to management of an R&D laboratory are:

1. For rapidly advancing technologies, <u>ceteris paribus</u>, prefer functional structures to project teams;

2. If the scale of the task is such that the assigned personnel

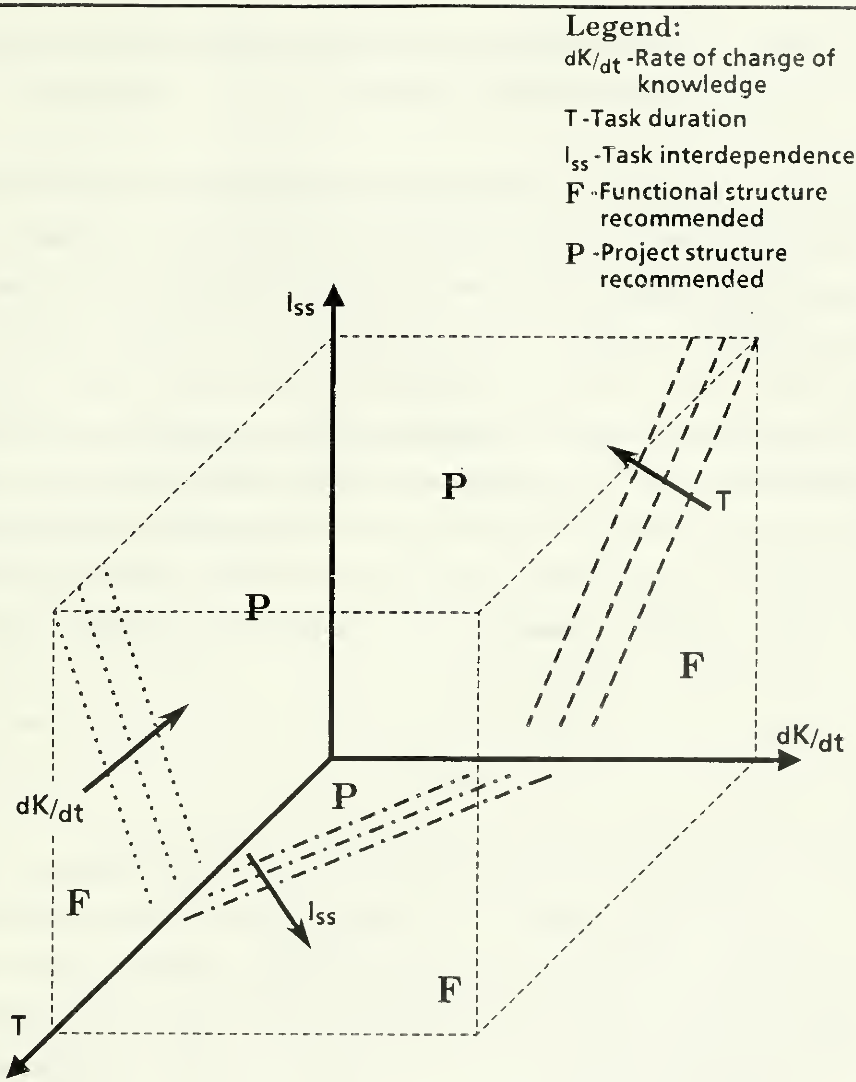


Figure 1: Organizational Structure Space

will be expected to spend a long period of time on the task, ceteris paribus, prefer functional structures;

3 Finally, if the sub-tasks of the joint effort seem to be highly interdependent, each influencing the other in an intricate way, ceteris paribus, prefer the project structure, which will accomplish effective coordination of these sub-tasks.

After proposing these general rules for organizational structure, which most effectively facilitate relevant communication by the task team, the question is -- what will be the influence on this model of information technologies, such as electronic mail, computer bulletin-boards, computer-conferencing, and scientific information retrieval technologies? Re-phrasing this, in what way might the prescribed division of the Organizational Structure Space into "Function" and "Project" be altered under the influence of new information technologies?

Although, as we emphasized before, there is still insufficient data for a meaningful answer as to whether or not communication-related information technologies are powerful enough to change individual and organizational behavior and performance, we can hypothesize that some of the functions which are at the present assigned to organizational structure might be assumed by these technologies?

## ALTERNATIVES FOR MEETING COMMUNICATION NEEDS

In the first two columns of Table I, we show two of the fundamental communication needs with their organizational solutions. In the third

column are possible alternative solutions drawing on information technologies.

The first possible impact derives from the fact that some information technologies could prove effective in meeting the need for coordination within a project team. This type of information system would accomplish a goal currently provided by the "Project" structure, obviating the need for direct, face-to-face, synchronous contact among project team members. Information technologies have now been developed, which are useful in attaining this same goal. For example, there are sophisticated forms of electronic mail in which forums are organized by topic. These forums can be further organized hierarchically into subtopics or sub-subtopics, each of which can be a subsystem, element or component of

Table I

Communication Need and Organizational and Technological Solutions

| Need | Organizational Solution | Information Technology Solution |
|---|---|---|
| Coordination of subsystem or sub-element work on a project | Project organization | -Hierarchically organized bulletin boards for project status reporting and configuration control |
| Knowledge transfer | Functional or departmental organization | -Document search and retrieval systems<br>-Expert system-based selective dissemination of information<br>-Bulletin-boards or forums for information search |

a project (Stevens, 1981). Status reports are maintained in these forums and regularly updated. They can also be used for queries and for managing interfaces among subsystems. Consequently, functional organizational structures might become feasible and effective even for highly interdependent technical tasks.

As the second hypothesis one could argue that improvements in information technologies will make it easier for technical professionals to maintain up-to-date technological know-how. The first technological analog that one thinks of for this type of organization is the document search and retrieval system. These have been around for many years and provide direct access to documentation files which by the end of 1984 numbered 3800 (Cuadra Associates, 1984). Although they have proven at best moderately successful for some disciplines or specialties, some can now be augmented by selective dissemination services based on artificial intelligence. These can learn a user's need and determine which journal articles or documents will be of interest. All of these systems unfortunately suffer from the same fatal flaw. They can provide the information, but it must still be read. And there is a substantial body of research to show that for the average engineers that is a very high barrier (Allen, 1984).

Knowledge is best transferred to engineers through personal contact. The connection to literature and documentation is best accomplished with the aid of intermediaries known as technological gatekeepers (Allen & Cohen, 1969; Allen, 1984). More recent developments in information technology may very well aid in the process of connecting an engineer to an appropriate gatekeeper. This is another adaptation of the computer

bulletin board. Some companies, for example, have encouraged the development of bulletin boards or forums that are organized around technical subjects. Anyone can send questions, or answers, or even dicta describing the ways things should be to one of these forums. Recent research (George, 1987) shows that there are key individuals associated with these forums who are usually experts on the particular subject and who supply very high proportion of the answers to queries that are entered. In other words, the forum serves as a mechanism to connect people to the appropriate gatekeeper. This can be very effective way of transferring knowledge in certain fields. At present, this seems more effective for software developers than for hardware designers.

## COMBINING STRUCTURE WITH TECHNOLOGY

The development of the new technologies affords an opportunity to use them to augment organizational structure. Despite their linking in the matrix form the project and functional structures remain mutually exclusive. An individual can either be directly integrated into a project team or kept in a functional department with a possible matrix connection to the project. If integrated into the project team, the coordination benefits are gained at the cost of greater difficulty in knowledge transfer. If left in a department, knowledge transfer is made easier at the cost of difficulty in coordination. What can now potentially be done is to use either the project or functional structure and augment that with the appropriate information technology to reduce its inherent cost.

In other words, when using project organization, individuals can be

connected to their knowledge bases by means of computer forums organized around their technical specialties. They thereby gain both the advantage of coordinating their work, and despite the organizational and physical separation from colleagues in their specialties, the advantage of keeping abreast of the state-of-the-art electronically.

When using functional departments, coordination of work can be accomplished by using hierarchically organized computer bulletin boards for configuration control and subsystem status reporting. This allows the team members to be dispersed among functional departments, thereby maintaining contact with their specialties, and coordinating their joint effort electronically.

On the basis of these arguments the hypothesized effect of information technologies on the Organizational Structure Space will be to move the dividing line between the project and functional regions in each of the three planes, changing slope and position as shown in Figures 2.

In the dK/dt--T plane we there are two opposing forces, the resultant of which will determine the boundary between functional and project structures. The more capable are the knowledge-enhancing systems (i.e., forums and retrieval systems) the larger will be the region in which project organization can be used. Conversely, the more capable are the coordinating systems (e.g., hierarchical bulletin-boards) the larger will be the area in which functional organization can be employed. On the other hand, because the two variables dealing with know-how transfer (change in knowledge aand task duration) are not differentially affected by technological treatment, we don't expect significant changes in the

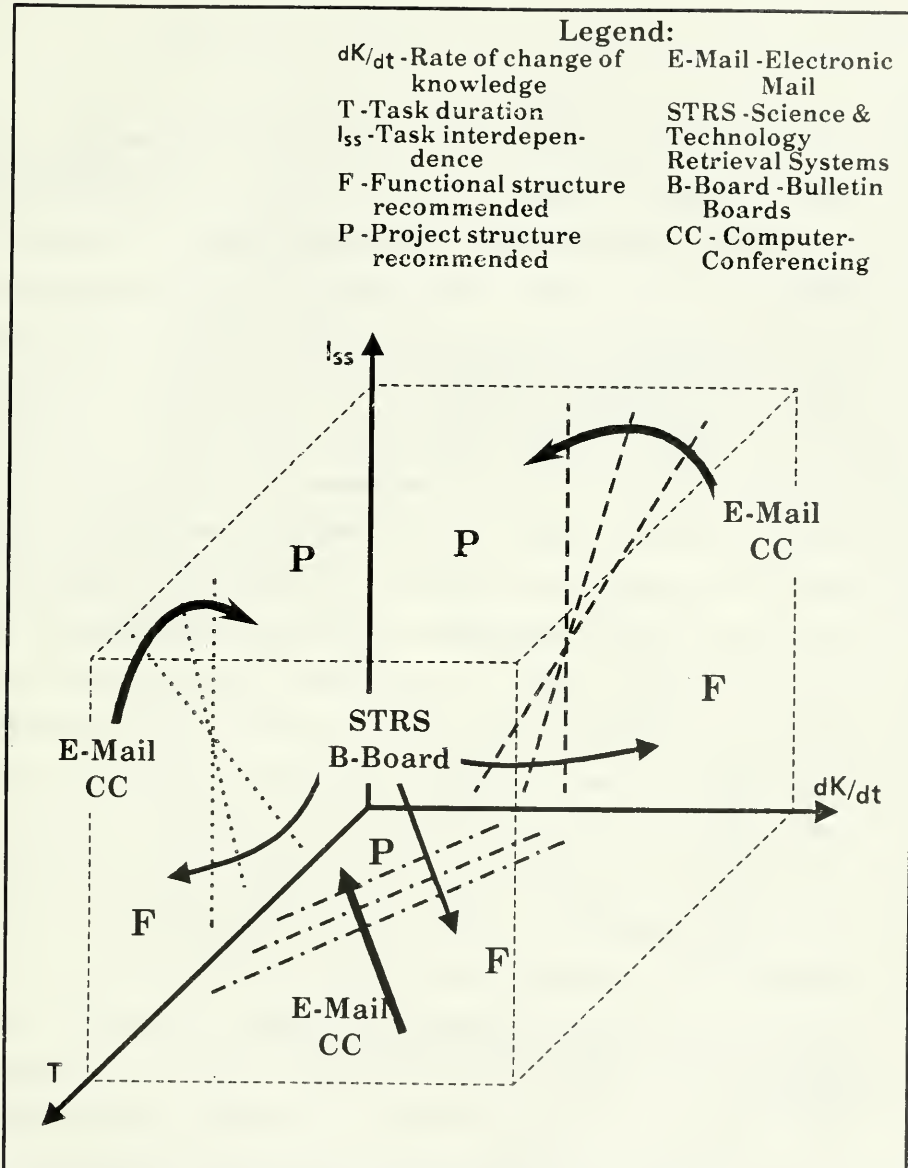


Figure 2. Influence of Information Technologies on Organizational Structure

slope of the function-project separating line in this plane.

In the dK/dt—$I_{ss}$ plane, there are also two forces which will operate in opposite directions. In this case, since one has more effect in dealing with subsystem interdependence, and the other with changes in knowledge, they will result in a rotation of the project-function boundary. Because the coordination requirements of the task may be more amenable to technological treatment, the dividing line will probably shift more toward the dK/dt coordinate, increasing the set of tasks for which the functional structure is recommended. The impact of document search and retrieval systems and of computer forums organized around specialties is expected to be somewhat less discernable for the reasons cited earlier. Even though documents can be located and retrieved, they still must be read. Forums, at this point, have been shown to be effective for software developers, but it remains to be seen how well they will work in other specialties. As a result, the location of the dividing line in this plane will shift only slightly from the $I_{ss}$ coordinate, somewhat increasing the set of tasks for which the project structure is recommended. Consequently the more significant shift, increasing the functional area, will occur for tasks of low interdependence and slow advancement of knowledge. On the other hand, the increase in the project area will be smaller and mostly for tasks of rapidly changing technologies and high interdependence. The net change in the set of tasks in the two structure areas will be a function of the power, effectiveness, and usability of the two information technologies.

This can be seen diagrammatically in Figure 3. This figure illustrates the tradeoff which exists between coordination and knowledge

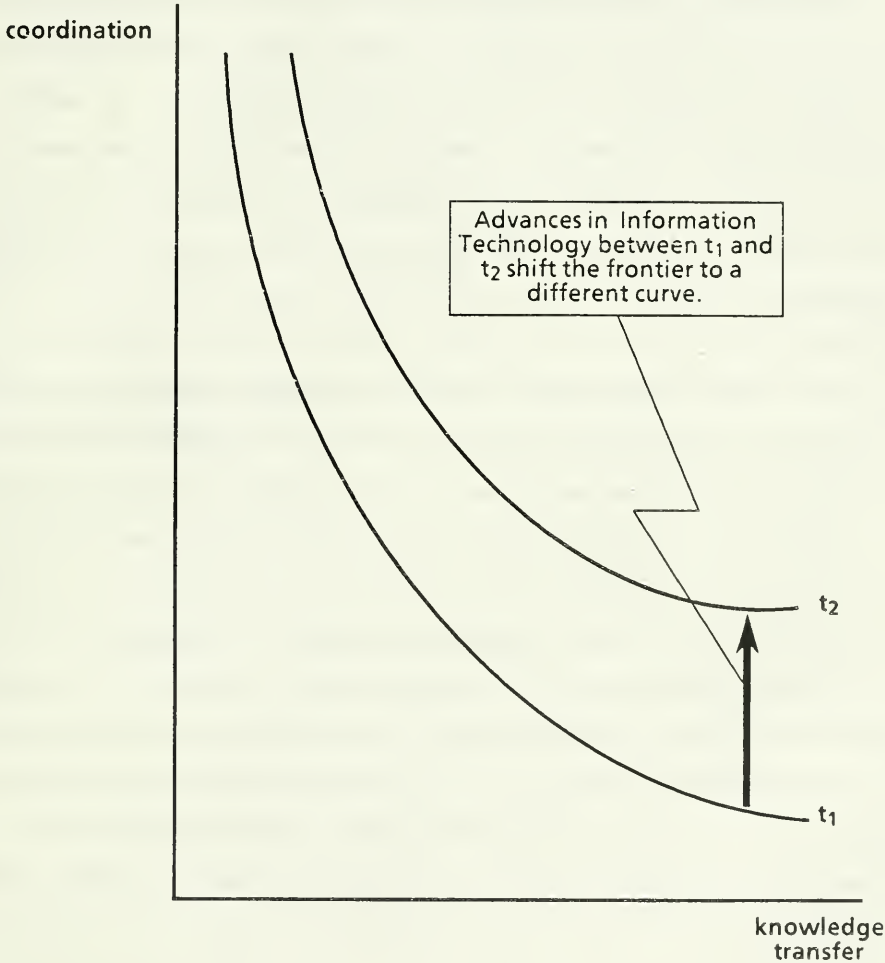


**Figure 3. The Tradeoff Between Coordination and Knowledge Transfer in Project Management**

transfer. Moving along one of the curves, better coordination requires the sacrifice of some knowledge-transfer, and vice versa. Improvements in the technology of communication cause a shift to a new curve. The new curve does not have to assume the same shape as its predecessor. Depending on whether the improvement is principally in the area of coordination or of knowledge transfer will cause a tilt of the curve in one direction or the other. In the figure, an assumption is made that the advances in technology will affect coordination more than knowledge transfer.

This added flexibility in task design through communication-related information technologies resembles the impact of Flexible Manufacturing Systems (FMS), on the traditional matching between product and process attributes (Hayes & Wheelwright, 1984, 209, 216). With the use of FMS, product variety, oriented towards effective achievement of customer needs, does not have to be necessarily traded off against efficient, large batch manufacturing of standardized products. This new information technology related capability makes feasible production systems which are both effective and efficient--a clear analogy to R&D project structures which will be able to achieve higher levels of efficiency in tasks of comparable requirements for innovativenss, knowledge transfer, and flexibility.

## PRACTICAL AND THEORETICAL IMPLICATIONS AND FUTURE RESEARCH

Managers can use the model described in Figures 1 through 3 not only to determine the preferred organizational form for a given situation, but also the choice of technology to effectively complement that choice. If

a decision is made to group individuals organizationally into a project team, then that team should be provided with technology that will enable them to stay in touch with developments in their specialties. They should be given access to retrieval systems and be acquainted with the use of forums for seeking answers to technical questions. An organization using the project form widely would be well advised to encourage the informal development of such forums.

If the decision is to retain people in functional departments, "matrixing" them to a joint effort, the provision of coordinating technology will certainly ease the project manager's job. Hierarchical bulletin-boards can be used to keep all team members informed of developments in those parts of the task that are of concern to them, or that would have an effect on their work.

Theoretically, the proposed conceptual model is one of many that are useful in studying organizational behavior. It will mainly apply at the task and departmental level, the operational and not the strategic organizational domain. The unit of analysis for a hypothetical study utilizing this model should be a group of professionals performing an organizational task. Although the model was defined with R&D tasks in mind, it will apply to any organizational tasks based on a changing field of knowledge, or expertise. This expertise does not have to be technical in nature; marketing or financial tasks, based on consumer behavior and economic knowledge will benefit from coordination-innovation oriented analysis, and from better understanding of what communication-related information technologies can do for their effectiveness and efficiency.

Thus defining the general domain of the proposed model, the next question will be how to operationalize it for empirical research. Although the suggested model does not preclude qualitative, ethnographic and case investigation, the final objective should be quantification of model's dimensions. This will not be easy, but there are certainly possibilities.

In basic scientific fields, dK/dt can be estimated by measuring the half life of citations to journal articles (Kessler, undated). There are other possible measures such as the slope of technical progress curves (Fusfeld, 1970) that might be more appropriate for applied science, and technology. These should be investigated in greater depth.

Subsystem interdependence can be estimated by project managers. Harris (1987) has shown that valid estimates can be made and that project performance has a very strong inverse relationship to subsystem interdependence. Harris's research reinforces previous research in this field (e.g., Thompson, 1967; Van de Ven, et. al., 1976) that interdependencies and the resulting interface problems seriously affect performance. It also emphasizes the need for solutions to the problem of coordinating work in highly interdependent projects.

But this only addresses our understanding of the static model of Figure 1. Research is also needed on the dynamics of the process which results from the introduction of information/communication technology. We need to know much more about the actual functions that can be taken over by the technology. Before that can be done, however, we must learn far more about the nature of the work itself. Much of this was done many

years ago for routine, mostly menial tasks (Taylor, 1911; Fayol, 1949) even to the point of analyzing feasibility of automation for specific functions (Bright, 1958). Recent work on "white collar," non-routine tasks (see examples in Fleishman & Quaintance, 1986) approaches the early work in degree of specificity, but much more remains to be done in this area in articulating task dimensions, and related research instruments.

Recent studies of communication-related information technologies (Hiltz & Turoff, 1982; Rice, 1980; Rice & Case, 1981; Picot, et. al., 1978; Steinfeld, 1984) have certainly improved our knowledge of these technologies and to some degree, their effects on the nature of work. Still, the MIS epistemology of technological dimensions and attributes is incomplete, and is mainly task related. Context-free typologies of these technologies should be quite useful for better matching of technologies and in this case--white collar tasks.

Table II

Communication Need and Organizational and Technological Solutions (Future)

| Need | Organizational Solution | Information Technology Solution |
|---|---|---|
| Coordination of subsystem or sub-elements of work | Project organization | -Hierarchically organized bulletin boards or forums for status reporting and configuration control |
| Knowledge transfer | Functional or departmental organization | -Document search and retrieval systems<br>-Expert system-based selective dissemination of information<br>-Bulletin-boards or forums for information search |
| Stimulation of creativity | Interaction enhancing techniques | -Computer mediated brainstorming<br>-Unstructured bulletin boards<br>-Computer/video conferencing systems |

Finally, even at the writing of this article additional advances in information technologies offer new capabilites to organizations, and raise new questions. As a case in point, how would the third determinant of R&D performance--creativity be achieved through organizational and technological means (Table II)? And how the proposed model should be modified to include creativity? To summarize we would like to emphasize that only rigorous empirical research will show the usefulness of theorizing, and the suggested theory is no exception to this rule.

## REFERENCES


Allen, D. E., and Guy, R. F. (1979). Ocular breaks and verbal output. Sociometry, 40, 90-96.

Allen, T. J. (1984). Managing the flow of technology. Cambridge, Massachusetts: MIT Press.

Allen, T. J. (1986). Organizational structure, information technology and R&D productivity. IEEE Transactions on Engineering Management, EM-33(4), 212-217.

Allen, T. J., & Cohen, S. (1969). Information flow in R&D laboratories. Adminstrative Science Quarterly, 14, 12-19.

Allen, T. J., Tushman, M. L., & Lee, D. M. S. (1979). Technology transfer as a function in the spectrum from research through development to technical services. Academy of Management Journal, 22(4), 694-708.

Allen, T. J., Lee, D. M. S., & Tushman, M. L. (1980). R&D perfromance as a function of internal communication, project management, and the nature of work. IEEE Transactions on Engineering Management, EM-27(1), 2-12.

Bright, J. R. (1958). Automation and management. Boston: Division of Research, Graduate School of Business Administration, Harvard University.

Cuadra Associates (1984). Directory of online databases. Santa Monica, California: Cuadra Associates.

Culnan, M. J. (1985). The impact of perceived accessibility on the use of integrated office information system. Presented at the Academy of Management National Meeting, San Diego, CA (August).

Daft, R. L & Macintosh, N. B. (1981). A tentative exploration into amount and equivocality of information processing in organizational work units. Adminstrative Science Quarterly, 26, 207-224.

Fayol, H. (1949). General industrial management, translated by Storrs, C. Ondon: Pittman & Sons.

Fleishman, E.A., and Quaintance, M.K. (1984). Taxonomies of Human Performance, Orlando, Florida, Academic Press.

Fusfeld, A. (1970). The technological progress function: A new technique for forecasting. Technological Forecasting, 1, 301-312.

George, F. (1987). Usage and Motivation of a Large Electronic Bulletin Board. Unpublished S.M. Thesis, Cambridge, MA: MIT Sloan School of Management.

Harris, M.S. (1987). Project Performane as a Function of Subsystem Interdependence for Multi-Site Projects, unpublished S.M. Thesis, Cambridge: MIT Sloan School of Management.

Hauptman, O. (1986a). Influence of task type on the relation between communication and performance: The case of software development. R&D Management, 16, 127-139.

Hauptman, O. (1986b). Managing software development: Communication as a success factor. Unpublished doctoral dissertation, MIT. Cambridge, Massachusetts.

Hayes, R. H., & Wheelwright, S. C. (1984). Restoring our competitive edge. NY NY: Wiley & Sons.

Hiltz, S. R., and Turoff, M. (1978). The network nation. Reading, MA: Addison-Wesley Publishing Co.

Jonansen, R., Vallee, J., and Collins, K. (1977). Learning the limits of teleconferencing: design of a teleconferencing tutorial. Proceedings of NATO Symposium on Evaluation and Planning of Telecommunication Systems. University of Bergamo, Italy (September).

Johansen, R., DeGrasse, R. (1979). Computer-based teleconferencing: effects on working patterns. Journal of Communication, 29, 23-34.

Katz, R., and Allen, T. J. (1982). Investigating the Not Invented Here (NIH) syndrome. R&D Management, 12, 7-19.

Kessler, M.M. (undated). Technical Information Flow Patterns, MIT Lincoln Laboratory Report.

Marill, T. (1980). Time to retire the telephone? Datamation, August, 185-186.

McKenney, J. L. (1986). The Influence of Computer-Communication on Organizational Information Processing. Boston, Massachusetts: Harvard Business School Working Paper 1-786-040 (Rev. 6/1986).

McKenney, J. L., Doherty, V. L., & Sviokla, J. J. (1986). The Impact of Electronic Networks on Management Communication - An Information Processing Study. Boston, Massachusetts: Harvard Business School Working Paper 1-786-041.

Pelz, D. C., & Andrews, F. M. (1966). Scientists in organizations: Productivity climates for R&D. New York: Wiley & Sons.

Perrow, C., (1967). A framework for the comparative analysis of organizations. American Sociological Review, 32, 194-208.

Picot, A., Klingenberg, H., and Kranzle, H. P. (1982). Organizational communication: the relationship between technological development and socio-economic needs. In Bannon, L., Barry, U., and Holst, O. (Eds.) (1982). Information technology impact on the way of life, 114-132. Dublin: Tycooly International.

Rice, R. (1980). The impacts of computer-mediated human communication. Annual Review of Information Science and Technology.

Rice, R., and Case, D. (1981). Electronic messaging in the university organization. Presented at the Speech Communication Association Conference, Anaheim, California.

Shilling, C. W., & Bernard, J. (1964). Informal communication among bioscientists. (Report No. 16A) Washington, D. C.: George Washington University Biological Science Communication Project.

Siegel, J., Dubrovsky, V., Kiesler, S., and McGuire, T. W. (1984). Group processes in computer-mediated communication. Committee on Social Science Research in Computing Working Paper Series, Carnegie-Mellon University, Pittsburgh, Pennsylvania (20 June).

Smith, R. B. (1985). The 21st-century corporation. Speech at the Economic Club of Detroit, Detroit, Michigan (September, 9).

Sproull, L. S. (1986). Using electronic mail for data collection in organizational research. Academy of Management Journal, 29, 159-169.

Sproull, L., & Kiesler, S. (1986). Reducing social context cues: Electronic mail in organizational communication. Management Science, 32, 1492-1512.

Steinfield, C. W. (1984). The nature of electronic mail usage in organizations: purpose and dimensions of use. Presented at the annual meeting of the International Communication Association, San Francisko, California (May).

Steinfield, C. W. (1985). Explaining Task-Related and Socio-Emotional Uses of Computer-Mediated Communication in an Organizational Setting. Working Paper, School of Communication, University of Houston.

Steinfield, C. W., & Fulk, J. (1986). Task demands and managers' use of communication media: An information processing view. Academy of Management Conference, Chicago (August).

Stevens, C. H. (1981). Many to many communication, Cambridge, MA, MIT Sloan School of Management, Center for Information Systems Research Working Paper no.72.

Taylor, F. W. (1911). The principles of scientific management. NY: Harper & Row.

Thompson, J. D. (1967). Organizations in action. NY: McGraw-Hill.

Tushman, M., & Nadler, D. (1978). Information processing as an integrative concept in organizational design. Academy of Management Review, July, 613-624.

Van de Ven, A. H., & Delbecq, A. L. (1974). A task contingent model of work unit structure. Administrative Science Quarterly, 19, 183-197.

Van de Ven, A. H., Delbecq, A. L., & Koenig, K., Jr. (1976). Determinants of coordination modes within organizations. American Sociological Review, 41, 322-338.

Watzlawick, P., Beavin, J. H., & Jackson, D. D. (1967). Pragmatics of human communication. NY: W. W. Norton.

Whitey, M., Daft, R. L., & Cooper, W. H. (1983). Measures of Perrow's work unit technology: An empirical assessment and a new scale. Academy of Management Journal, 26, 45-63.